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REPAIRING SHIPS.

WE have once or twice alluded to the necessity of Submarine Telegraph Companies possessing properly fitted steamers for the repair and maintenance of their lines. Yet we can hardly find fault with private companies for not having cable ships of their own, when our own Government sets the example of false economy by remaining entirely dependent on the casual hire of a steamer for the repair and maintenance of their cables.

The Electric Telegraph Company, whose lines formed the greater portion of the system transferred to the Post-office, had a repairing ship of their own, and this ship was made over to the Government, but, being worn out, was condemned, and has never been replaced; and although designs for a new ship have been made and approved, and tenders sent out some three times, the Lords of the Treasury have each time repented of their step so far, and have retreated with buttoned-up pockets. The consequence has been that, under pressure of broken-down communications, a fully fitted ship has to be hired, and the expense that has been incurred by chartering ships for each repairing expedition, as compared with the cost of buying and maintaining one, must be very great, and would form an interesting subject for a question in the House of Commons. The ships hired are generally larger than necessary for the work; indeed, for some work, their size is a positive disadvantage. But, besides this, the hiring of a ship must always be preceded by negociations which, even between companies or firms, must take time. With all the encumbrance of government official correspondence this must still be greater, and during this period communication is stopped. Moveover, the case might easily occur that no fully fitted cable ship was disposable, as they are not so very numerous, and thus the government would have to hire a steamer and fit her out, an operation that would occupy several weeks.

Nearly all companies and administrations having submarine cables have learnt, sooner or later, by their own experience, when they have ignored the experience of others, the absolute necessity of having at their constant disposal a ship ready to repair and maintain their lines, and the Government have simply gone a step backwards from the preceding owners of the telegraphs in thus neglecting to supply the place of the *Monarch*.

The "*Monarch*"—the "*old Monarch*," or "poor old *Monarch*," as she was at last affectionately called, was *the* first permanent repairing ship. She was a paddle-wheel wooden steamer of 427 gross tonnage, built in 1830, and bought by the International Telegraph Company in 1853, and from her were laid the first cables between England and Holland. In 1854, she was fitted with the first drum "Picking-up" gear, and in her the first systematic operations connected with the repair of cables were executed. She continued to be employed at this work until the transfer of the telegraphs to the Government, and soon after was condemned. The Submarine Telegraph Company, who for some time employed Liverpool tugs, at last built the *Lady Carmichael*, paddle-wheel steamer. The Indian Government, in 1863, bought the *Charente*, a small screw-steamer, re-named her the *Amberwitch*, and fitted her as a repairing ship for the Persian gulf cable, where she has been employed ever since. The Anglo-American Company bought the *Robert Lowe*, since wrecked, which was followed by the *Minia*, their present repairing ship. The Eastern Company possess the *Chiltern* and the *Hawk*. The Eastern Extension Company have now the *Agnes* and the *Edinburgh*. The Great Northern Company possess the *Œrsted;* the Western Brazilian Company the *Norseman;* and the West India and Panama, the *Investigator*. The American International Ocean Company possess the *Professor Morse* (formerly the *Suffolk*), and the French Government had for some time a small steamer called the *Ampère*, which has since been replaced by a larger vessel called the *Charente*. The Direct United States Company have no repairing ship of their own, but employ the *Faraday*, and the Anglo-American Company, besides their permanent ship the *Minia*, are now employing the *Hibernia*.

It will be seen, therefore, that the necessity for repairing ships has become generally acknowledged. Indeed, with the exception of the Brazilian Submarine Company, our own Government are the only important administration possessing cables without the means of dispatching a ship to repair a fault within a few hours after the interruption of a cable.

For a perfect repairing ship, many qualities are required, but, perhaps, the most important is that of being capable of turning without "way" through the water. Disconnecting paddles effect this, but if there are only a pair of engines, there is the disadvantage of the dead point, besides the cumbrous nature of the disconnecting gear if the ship is large. A pair of engines to each wheel overcomes the dead point question, but this increases the machinery. The plan adopted by Mr. Siemens, in the *Faraday*, of twin screws, the shafts of which converge towards a point astern of the ship, is

very good. In the *Hooper*, a small screw placed at right angles to the driving screw in the dead wood was adopted, but failed. Both paddles and screws are, however, sometimes in the way when slipping bights or dealing with buoys. The system of hydraulic propulsion, employed in the gun-boat *Waterwitch*, would be excellent for a cable ship, as there are neither screws nor paddles, but only a box-like structure, about a foot square in section, running a short distance along the side amidships, and tapering off on its top and bottom side, so that it could not foul a boat, buoy, or rope. The ease with which one propelling stream can be reversed in an instant, without stopping the engines, would be of immense advantage in a cable ship.

No repairing ship has, we believe, as yet been built expressly for the purpose, but let us hope that some day some company or government will set an example by building and fitting a proper and convenient ship for a branch of telegraphic work which is every day becoming more important.

ON TELEGRAPH CONSTRUCTION.

By JOHN GAVEY.

(Continued from vol. iii., page 295.)

5.—The Erection of the Line.

We propose first to consider the mechanical principles involved in providing for the stability of the line, and in order to do so satisfactorily, it is necessary to define briefly a few of the terms used in mechanics, and to glance at a few of those laws which bear directly on the subject.

Force is simply described as any cause which moves, or tends to move, any portion of matter.

Matter is considered as anything which may be perceived by the senses, or if considered as the converse of force, it may be described as any substance susceptible of being acted upon by a force.

Force is evidenced in its action upon matter, either by its exerting a pressure thereon, or by its imparting motion thereto. The former is dealt with in treatises on mechanics, under the head of Statics, the latter under that of Dynamics.

Force is measured in two ways. In one termed the gravitation measure, the weight of a given mass of matter at the earth's surface is taken as unity, all other forces being compared therewith. The early unit of force adopted in this country was that of the imperial pound averdupois, or in other words the attractive force of the earth on that definite mass of matter. This unit, although an accurate measure of mass, is not an accurate measure of force, inasmuch as the attraction of the earth itself varies as between the equator and the poles; but this variation is so small, amounting only to a difference of 22 grains in 7,000, between London and the equator, that it does not materially affect the correctness of ordinary problems with which a mechanical engineer has to deal.

Force is likewise measured by the motion it can impart to a given mass of matter. It can be proved experimentally, that the motion imparted to a given mass varies directly as the amount of force acting on that mass, or in other words, the velocity of the mass, acquired by the force acting on it for a given period, will be the measure of the force. This measure may be termed the absolute or dynamical measure of force. It is evident that before this unit of force can be defined the units of time, space, and mass must be determined. The unit of time taken is the second, the unit of space the foot, and the unit of mass the imperial pound, the unit force being then described as that force which, acting for one second, will impart a velocity of one foot per second to a mass of one imperial pound. It has been proved experimentally, that the attraction of the earth will impart to a body, falling freely in vacuo, a velocity of 32·2 ft. (approximately) per second, or 32·2 units of dynamical force; so that the unit of force under this definition would be 1-32·2 of the attraction of the earth on a pound of matter; in other words, about half an ounce.

Forces are generally represented by straight lines, the direction of the lines representing the direction of the forces, and the length of the lines their magnitude. Thus, if a force of say 10 lbs. act upon a mass of matter, it may be represented by the line A B (fig. 3) drawn in the direction of the force, and of a length of say 10 inches, or fractions of an inch. This admits of many problems in mechanics being solved by geometry and trigonometry.

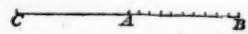

Fig. 3.

If a second force A C, likewise of 10 lbs., act in precisely an opposite direction to A B, it is evident that it will balance the latter, and the point A will have no tendency to move in either direction under the joint influences.

If, however, two forces, A B, A C, fig. 4, not in

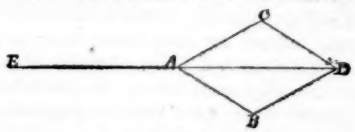

Fig. 4.

the same straight line, act upon A, it becomes necessary to ascertain, first, the direction in which A will move, and, secondly, the force with which it will move in that direction. This and the converse, viz., the finding of two forces, acting at a given angle, equal to a given force, is termed the composition and resolution of forces; the two forces, A C, A B, being the components, and the third force, equal in action to the other two, the resultant.

This problem is readily solved by what is termed the parallelogram of forces. In fig. 4, let the two forces, A B, A C, act on the point A, and be inclined to one another at the angle B A C; mark off on A B and A C, as many inches, or fractions of an inch, as the forces A B and A C contain pounds; then through the point B, draw B D parallel to A C, and through C, draw C D parallel to A B; join A D—then A D, the diagonal of the parallelogram A B C D—is the resultant of the forces A B, A C, and represents both the direction

and the amount of force with which A would tend to move under the joint influence of A B and A C, or, in other words, the number of inches or fractions of an inch in A D, would represent the number of pounds pull on A in the direction A D. Then, if it were necessary to find a force which would just balance A B, A C, extend the line D A, and mark off A E equal to D A. The force A E will exactly balance the two forces A C, A B.

The resultant of three or more forces may be obtained by ascertaining the resultant of two of them, then the resultant of this and the next, and so on.

To resolve the single force A D into two forces acting at any given angle, draw two lines A C, A B, in the given directions, then through D draw D C and D B parallel to A B and A C. Then A B and A C represent the magnitude of the forces equal to A D.

Further, if three forces acting on a point be represented in order by the sides of a triangle, they will be in equilibrium; or, each will balance the other two. Let these forces be represented by the sides A C, C D, D A, of the triangle A C D, fig. 4, then completing the parallelogram A C D B, and producing the diagonal A D to E as before, then A E balances A B and A C; and A B being equal to C D, the three forces are correctly represented, in magnitude and direction, by the three sides of the triangle. This affords a ready means of calculating the strains on triangular structures.

As a matter of fact, the distribution of forces is, in practice, calculated by trigonometrical formulæ. The scope of these articles does not admit of our dwelling longer on this subject, which is fully treated of in ordinary works on mechanics. It is simply necessary to quote the formula in geneal use. Taking x and y as two forces, θ the angle they enclose, and r the resultant, then

$$r^2 = x^2 + y^2 + 2\,xy\,\text{Cos}\,\theta$$

When x and y are equal, the formula is resolved into the following:—

$$r = 2\,x\,\text{Cos}\,\frac{\theta}{2}$$

The latter formula is that which enables us to calculate the strains of wires on angle poles. As in practice, although the spans vary frequently on either side, the method adopted in tightening the wires equalizes the strains.

The next point for consideration is the action of parallel forces on a rigid bar.

If two parallel forces P and Q (fig. 5) act on a

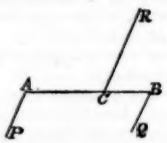

Fig. 5.

bar A B, it can readily be demonstrated, that they are balanced by a force R, parallel and equal to their sum acting at a point C, such that the following proportion is established:—

$$P : Q :: BC : AC$$

If the forces P and Q and the length A B only, be given, the locality of C may be found, from the following proportion:—

$$P + Q : P :: AB : BC$$

$$\text{or}\quad P + Q : Q :: AB : AC$$

$$\text{whence}\quad BC = \frac{P \times AB}{P + Q}$$

$$\text{and}\quad AC = \frac{Q \times AB}{P + Q}$$

The resultant of three or more parallel forces can be obtained, by finding that of two of them, then the resultant of this and a third and so on—

The action of parallel forces brings us naturally to the consideration of the principle of the lever. A lever is briefly described as a rigid rod, moveable around a fixed point of support, termed a fulcrum. The fulcrum divides the lever into, or determines two parts, termed the arms of the lever.

Levers have been divided into three kinds, in the first of which (I. fig. 6), the fulcrum is between the two forces A and B, and in the second and third (II. and III. fig. 6) the latter are

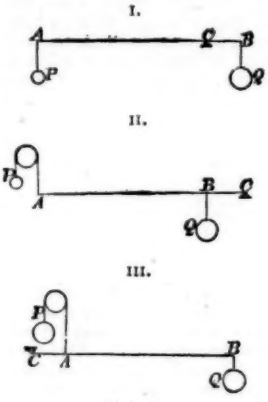

Fig. 6.

on one side of the fulcrum. The distinction is, however, of little practical value, as the same law governs the action of each.

It is evident that the two forces, (fig. 6) P and Q, acting at right angles to the lever A. B., tend to turn it in opposite directions, and it can readily be demonstrated, that equilibrium is established when the force P multiplied by its distance A C from the fulcrum, is equal to the force Q. multiplied by C B. These results are termed the moments of the forces P and Q about C., and this law applies to all description of levers, whether straight or bent, viz., that when the moments, or in other words, the product of the forces into their perpendicular distances from the fulcrum, are equal, they balance one another.

The application of the foregoing laws enables us to calculate the strains on beams. A beam fixed at one extremity only, is termed a cantilever; as for instance, an ordinary telegraph pole fixed in the ground and not stayed. A beam supported at both ends, is generally termed a girder, and a

telegraph pole when stayed, or strutted, may be considered as one of the latter class.

If we consider a cantilever A C, fig. 7, securely fixed at right angles to a wall, with a weight attached to one extremity, and disregarding for the present the weight of the beam itself, the moment

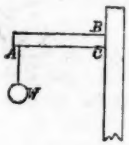

FIG. 7.

of the force tending to cause fracture at B may be represented by W, multiplied by the length A C, the opposing force, or the resistance to fracture, being the specific strength of the material itself, multiplied by C B, the short arm of the lever, C being regarded as the fulcrum. Thus, if A C were 4 feet in length, B C 1 foot, and it took a strain of 1,000 lbs. suspended at A to break the lever at B, then 1,000 lbs., multiplied by 4, the length A C, and divided by 1 (B C) = 4,000 lbs., the breaking strain at B. If the weight W were uniformly distributed over A C, then, from the theory of parallel forces, it would be equivalent in effect to an equal weight applied at D, the middle of the cantilever,

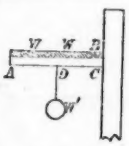

FIG. 8.

and as it would have from this point but half the moment, the length of the lever being reduced by half that it had in the former case, it would exert a strain of 2,000 lbs. only at B. Assuming as before that a force of 4,000 lbs. at this point is required to cause rupture, double the former weight, or 2,000 lbs. uniformly distributed over A C, would be needed to break the beam at B.

If the beam A D were supported at both ends,

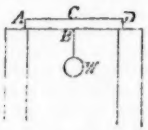

FIG. 9.

with the weight W (1,000 lbs.) suspended in the centre, then it is evident that the supports A and D would each sustain half the weight, or the effect would be the same, from the reaction of the supports, as though a pressure of 500 lbs. were exerted in an upward direction at A and D. But 500 lbs., with a leverage of 2 feet (D to C), divided by 1 foot (B C), would only exert a breaking strain of 1,000 lbs. at B; and as 4,000 lbs. is the assumed limit of strength, or the force necessary to cause rupture, in this instance it would evidently require 4,000 lbs. at C to break the beam under these circumstances.

A like reasoning will show that if the weight of

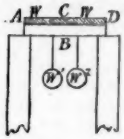

FIG. 10.

1,000 lbs. were uniformly distributed over a similar beam, fig. 10, it would be equivalent to two separate weights of 500 lbs. each at one-fourth the length of the beam from the supports, and that, under these circumstances, eight times the original weight, or 8,000 lbs. would be necessary to cause rupture.

We thus obtain the following relative strengths of similar beams according to the manner in which they are supported:—

Beam (cantilever) supported at one end, and weighted at the other, 1.

Beam (cantilever) supported at one end, and uniformly weighted, 2.

Beam (girder) supported at both ends, and weighted in the centre, 4.

Beam (girder) supported at both ends, and weight uniformly distributed, 8.

In practice, the weight of the beam which is here neglected has to be taken into consideration.

MILITARY TELEGRAPHY.

SYSTEM OF M. TROUVÉ.

THE system of military telegraphy, invented by M. Trouvé, deserves to attract attention for two reasons; in the first place it furnishes an apparatus complete and sufficient in itself, and all that is required in the majority of cases; and, on the other hand, it has already been adopted by more than one European army, that is to say, it is not a new thing recommended only by the inventor, but a contrivance which has, up to the present, been appreciated by competent judges. The apparatus consists of a two-wire cable for connecting the two stations, a battery and a speaking instrument. Fig. 1 represents the line and the two stations, or, to speak in less technical language, the two correspondents. The officer to the right has selected his point of observation. He carries on his belt a battery, which you see at his side, and a telegraph instrument which he can put in his pocket, or hang on his epaulet between the intervals of corresponding.

The soldier who is at some distance to the left, carries on his back a bracket, similar to those used by the commissionaires in Paris; on this bracket, on the upper part, there is a large bobbin, on which is wound the cable, and on the lower part, the battery; and in addition to this he has a telegraph instrument, which is at the moment under con-consideration, suspended high up on the left side of the bracket.

In proportion as the soldier advances the cable unwinds itself and falls on the ground, the bobbin turning on its axis; the time for corresponding

having arrived, he unhooks the little telegraph instrument, and taking it in his hand begins to receive or dispatch the necessary communications. This correspondence can be maintained without his even stopping his march, nor is it necessary that all the cable should be uncoiled; there is a kilometre of cable on the bobbin, so that after traversing a thousand metres he will be obliged to stop, but he can correspond equally well at a shorter distance, 500 metres, for example, as the communication always passes through the entire cable, whether it is on the ground or on the bobbin.

The cable consists of two insulated conductors, both of which are covered with gutta-percha, and the two are held together under a covering of india-rubber. With this protection it can be laid on ground either dry or moist, and can even be exposed to rain, or can traverse a brook without any hindrance to the communication. We should here remark that owing to the small electric resistance of the line, a slight leakage would be but of slight importance. The two conductors are joined to the battery of the stationary officer before the separation of the two telegraphists; the special terminals are lettered, so as to give rise to no mistake. Before starting they test their apparatus, by sending a short sentence in each direction.

After having again taken his position, the moveable telegraphist advises his correspondent by sending the word of command, and the exchange of messages can commence. The soldier carrying the bobbin seeks out paths inaccessible by carriages; if he has a certain route to traverse he would give preference to a locality where the trees would allow him to carry the wire sufficiently high to allow carriages and cannons to pass beneath it, for it will be understood that if the wire was laid along the road it would run the risk of being crushed and cut by wheels passing over it. Practically, for this and analogous reasons, it is necessary to furnish the telegraphist with an assistant, for lifting the cable on the branches of trees and for various other emergencies. Further, when it is time to cease the communication, the telegraphist receives the order to return to the starting point, and there again a companion is necessary to wind up the cable on the bobbin, by means of a handle which is attached to the end of the axis to the right of the bobbin (fig. 2); he turns this and winds up the wire while the carrier walks slowly to facilitate the operation.

We have here shown two telegraphists, one stationary, the other moveable, separated by a maximum distance of a thousand metres. But the second may be accompanied by a third carrier, with a bobbin, &c., exactly the same; and when one of the carriers has expended his cable, the second begins to unwind his, a connection having been established between the two cables by means of igeniously contrived joints. It will then be possible to establish a communication between two points, two or more kilometres distant without any change in the system.

FIG. 1.—MODE OF LAYING DOWN THE MILITARY TELEGRAPH OF M. TROUVÉ.

To make the whole utility of this simple contrivance clearly understood, the following point must be borne in mind, that in a case of great emergency, a line one kilometre in length, can be laid on open ground in ten minutes; that is to say, in the time requisite to traverse this distance on foot. It will be remarked that in the foregoing we have spoken of a two-wire cable; although in ordinary telegraphy only one wire is used, and the earth is made use of to supply the place of a return circuit. On reflection, it will be seen that this flying telegraph does not operate under ordinary conditions; the formation of a good earth

connection is, in fact, indispensable at each station, but military telegraphists cannot always select a spot suitable for this connection with the earth, and, further, it can very rarely be made in a very short time. In the deserts of sand, baked by the sun (in Algeria for example) an earth connection could not be made; in a plain, frozen several feet deep, or such as were the campaigns during a notable part of the last war, it would be quite impracticable. These reasons have led M. Trouvé to employ two conductors, and to disregard the rules of the service in ordinary telegraphy, and with good reason, although military telegraphy should not, as a rule, always be conducted in this way. If one had to employ Trouvé's telegraph for long distances, it would be expedient to use the

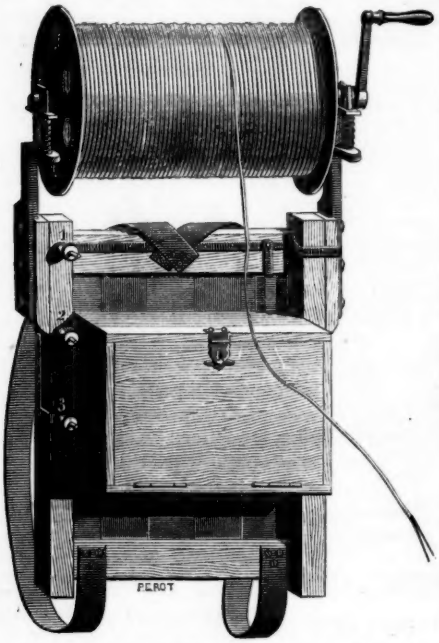

FIG. 2.—MILITARY TELEGRAPH OF M. TROUVÉ. THE BOBBIN AND THE BATTERY.

two conductors for the sending wire, and employ the earth for a return circuit. The line of telegraph proper, which is the most essential part of an electric telegraph, having been thus considered, the speaking instruments are only accessories, and can be contrived in several ways. M. Trouvé has designed two consecutively; one is a dial instrument, very similar to the Brequet's telegraph; the other is an apparatus on the Morse system, for reading by sound, which is called, in technical language, a speaking instrument. For the present the latter only will be described.

The speaking instrument called Trouvés' speaking instrument, is represented half size in fig. 3; it is the size of a large watch, and can be carried in the pocket; the case is of metal, and is generally made in brass nickelized. The instrument is drawn with one of its sides open, so as to show its mechanism, which is for the most part very simple.

An electro-magnet is the chief agent; its armature placed on the top of it has a slight movement around a centre on the side facing the spectator. This armature beats against a button fixed on the back side of the case. Little taps produced thereby make sufficient sound to be easily read with a suitable battery, without its being necessary to apply the instrument to the ear. It will be perceived that the case of the instrument acts as a sounding board and assists considerably the clearness of perception.

The manipulator or morse key is placed on the exterior of the box; it is a little lever which turns on a centre, and the extremity of which is raised; the manipulation can be made with the end of the forefinger of the right hand, the instrument being held in the left hand. Formerly M. Trouvé had

FIG. 3.—TROUVÉ'S SPEAKING INSTRUMENT, (HALF SIZE).

designed another arrangement still more compact, the manipulation was performed by means of a knob placed within the suspension ring, similar to that in a watch which winds without a key. It is not improbable that this form, which offers less chance of derangement, will be reverted to.

Three insulated conducting wires are attached to the apparatus, and serve to connect it with the battery and line. These conductors are each formed of several very fine copper wires plaited together, which give extreme pliability to the whole; they are each covered with silk of a special colour, and in addition, the little hooks which terminate them are numbered, and these numbers correspond with the numbers of the terminals on the case of the battery to which they should be attached, so that in spite of the feverish excitement with which these connections are sometimes

made, it does not seem possible to make a mistake. It now only remains to speak of the battery itself, which is not the least important part of the apparatus, and which presents advantages quite incontestable. This subject is reserved for another article, but as far as we have gone, the reader has seen the main character of the military telegraph of M. Trouvé, which is the collection of all these parts (cables, battery, receiver, and manipulator), on the back of a man; all this together in appearance like the knapsack of a soldier, and of less weight.

VOLTAIC ELECTRICITY.

By PROFESSOR TYNDALL, D.C.L, LL.D., F.R.S.

LECTURE III.

(Continued from page 176.)

In company with Ampère, Arago magnetised steel needles by the voltaic current, developed in helices of copper wire. The question naturally followed, What is the state of such a helix as regards magnetism? Tested by the magnetic needle, a long helix was found to have two poles, one north, the other south; and that when suspended so as to be free to move, it sets itself with its core precisely in the magnetic meridian, the wire through which the current is conveyed being then directly across the meridian. (A flattened helix likewise sets itself with its core north and south.)

The poles of a second helix brought to bear upon the first, attract one end and repel the other, and, in fact, act as if they were the poles of a bar magnet.

It was by this course of research that Ampère was induced to conceive the act of magnetization as the setting of molecular currents parallel to a common direction. Faraday endeavoured to discover whether the mutual attraction of such currents did not shorten a magnetized bar. Joule, however, proved the bar to be lengthened by the act of magnetization.

We may regard a bar of iron as made up of particles united by the force of cohesion, but still, to some extent distinct. When iron is broken we see crystalline facets on the surface of fracture. In fact the bar is composed of minute crystals of irregular shape. These when the bar is magnetized, try to set their longest dimensions parallel to the direction of magnetization, that is to say, in the direction of the bar itself. They succeed in this effort to some slight extent, and thus produce the minute and temporary lengthening of the bar. This is the explanation of De la Rive. It is as true as it is acute.

Magnetic oxide of iron may be suspended as a powder in water, contained in a cylindrical vessel with flat glass ends. Let the vessel be surrounded with a coil of covered wire. Looking at a candle through the muddy liquid, and making the coil part of a voltaic circuit, the candle brightens at the moment the circuit is made. Breaking the circuit, dulness again supervenes. This is due to a particular arrangement of the particles of suspended oxide. They set their longest dimensions parallel to the beam of light, and thus obstruct its passage less. They also attach themselves end to end, and form lines like the lines of iron filings. (This beautiful experiment is due to Mr. Justice Grove. Projecting a magnificent image of the end of the cylindrical cell on a screen, and sending through it the beam of the electric lamp, whenever the circuit was established, an illuminated disc, two or three feet in diameter, flashed out upon the screen).

If a naked wire forming part of a voltaic circuit be wound round a bar of iron, the power of which the wire was the vehicle is in great part transmitted to the iron, which becomes part of the circuit.

But if the wire be overspun with cotton, or still better with silk, this transmission of the power from the wire to the iron bar is prevented. The wire may then be coiled round the bar while the power is compelled to pass in succession through all the convolutions of the wire. Here the iron bar is not at all in the circuit.

But though not in the circuit, the iron, as shown by Sturgeon, is powerfully excited by the surrounding wire. Every convolution of the wire evokes a certain amount of magnetism in the bar, and by rendering the convolutions sufficiently numerous a magnet of enormous strength may thus be generated.

Such a magnet is called an electro-magnet, to distinguish it from ordinary permanent steel magnets. When the circuit is broken, the power of the electro-magnet ceases. It then falls from its highly excited state to that of ordinary iron.

For electro-magnetic purposes the covered wire is usually coiled round a hollow reel, several layers of coils being sometimes superposed upon each other. Such a reel is called an "electro-magnetic helix." The iron bar to be magnetized is placed within the helix, forming its "core." The electro-magnet may be either straight, shaped like a horseshoe, or it may be caused to assume other forms.

The smooth bar of iron placed across the ends or poles of a horseshoe magnet is sometimes called a "keeper," sometimes an "armature," and sometimes a "sub-magnet."

It is not necessary that the convolutions of a helix should be close to the core. A hoop, for example, a yard in diameter, round which covered wire is coiled, magnetizes an iron bar placed across it at its centre. The magnetized body is here nearly 18 inches from the magnetizing coil. How is the power transmitted from the one to the other? Is it action at a distance, or does it require a medium for its propagation? This is a question which at present profoundly interests investigators.

An electro-magnetic helix, as already shown, even without a core of iron, behaves like a magnet. It attracts iron. Its two ends, moreover, are opposite poles, and between them is a magnetic equator. When, however, a core is placed within the helix, the magnetism of the combined system is far more intense than that of the helix alone.

The strength of a magnet is measured by its power to deflect a magnetic needle from its meridian; the magnetic strength of a helix alone, and of a helix and core combined, are similarly determined. To obtain the magnetic strength of the core, we first determine the strength of the helix alone, and then of the helix and core combined. Substracting the former strength from the latter, we obtain the magnetic strength of the core.

If the cores be thick, and of good iron, the

magnetic strength of the core is, within wide limits, proportional to that of the helix. With thin cores the law of proportionality soon fails; as if, in their case, the molecular currents of Ampère were soon forced into their positions of maximum action, further magnetization producing no effect.

Notes.

We regret having to state that Sir William F. Cooke, to whose persevering efforts, forty years ago, to render the telegraph of practical use the world is so much indebted, has been suffering from a severe illness for the past three months, from which we are happy to state, however, he is now recovering. We expected that we should have been enabled to present our readers with a portrait of Sir William very shortly, but, although this is, through the illness of Sir William, for the present unfortunately postponed, we have every hope that at a future date we may be able to do so.

A portrait of Mr. Latimer Clark has been taken by Mr. Mayall, of Regent-street, and is in the hands of the Woodbury Company for reproduction for this journal.

Mr. J. R. France, formerly engineer to the Submarine Telegraph Company, who so ably and successfully superintended, on the part of the Hooper's Telegraph Company, the laying of the cables of the Western Brazilian Telegraph Company, has been appointed manager for the Western Brazilian Company at Rio Janeiro.

The s. s. *Hibernia* has been hired from the Telegraph Construction and Maintenance Company by the Anglo-American Telegraph Company for the repair of the French Atlantic cable. Mr. J. C. Laws, the chief marine electrician of the Construction Company, and Mr. London, Telegraph engineer of the same firm, are entrusted with the work. The ship left the Thames on the 18th ult. The s. s. *Minia*, which was sent to this work when the cable first broke, left on the 18th of May for Placentia to repair the Placentia and Cape Breton cables. The French Atlantic cable was repaired on the 26th.

The s. s. *Dacia*, Captain Hilliard, belonging to the India-rubber, Gutta-percha, and Telegraph Works Company left the Thames on the 15th ultimo for South America with the telegraphic cable to connect Valparaiso, La Serena and Caldera, in completion of the West Coast o America Telegraph Company's system. Mr Benest is in charge of the cable and staff, and Mr. R. K. Gray, we believe, takes charge when the work is commenced.

Mr. Lambert, of the firm of Clark, Forde and Co., proceeds by South Pacific mail to join the expedition at Valparaiso to test the cables and report on the work on the part of that firm, a duty which Mr. Lambert performed during the operations connected with the cables already laid, of which Messrs. Clark and Forde give a very satisfactory account in their report.

The cable of the Eastern Extension Company, between Singapore and Batavia, which broke down on May 31st was repaired on June 7th.

The Committee of the House of Commons on the Postal Telegraphs have concluded their sittings for the the collection of evidence, and we believe their report will shortly be presented.

The *Railway News* of June the 17th, states that Jersey is singularly unfortunate with regard to its telegraphic communication. A fortnight ago, as then reported, a fracture occurred in the cable lying between England and Guernsey, about 35 miles distant from that island, and the repairs are not yet effected, in consequence of the non-arrival of the requisite steamer. To add to the inconvenience experienced, the cable belonging to the Submarine Telegraph Company, lying between Jersey and the coast of France, ceased working on Monday, and no communication has since been obtained with the continent. Jersey is thus cut off from all telegraphic connection with England and France. Since this it has been announced that the interruption to communication between Jersey and France was due to a defect in the land line, close to its junction with the cable.

The s. s. *International*, belonging to the India-rubber, Gutta-percha, and Telegraph Works Company, has been chartered by the Post-master-General for the repair of the Channel Islands cable, and left the Thames on the 21st ultimo. A staff of cablemen from Lowestoft, under Mr. D. Lumsden, electrician of the postal telegraphs, is on board. After the repairs of the Channel Islands cable, the ships proceed to the Pentland Frith, in order to restore Telegraphic communication with the Orkneys.

The Channel Islands cable was repaired on the 24th. This is very quick work.

In our issue of June the 1st we quoted from the *Moniteur Industriel Belge* the description of an Electro-motive Machine, by M. T. Chutaux, of Paris. Several of these machines are now on view at 17, St. Bride Street, Ludgate Hill. The armatures, of which there are ten in the smallest machines, are each made of seven thin plates of soft iron, separated by zinc plates. This division, M. Chutaux states, increases the attractive power by

the increased surface exposed to the magnetic field. The contacts at the commutator are made by small wheels pressed against the revolving "make and break" piece by springs. The constant change of metal surface, exposed to the action of the spark, prevents the destruction of the contact which occurs when rubbing surfaces are used. The batteries employed have graphite negative plates surrounded by broken graphite in a porous cell, and charged with bicromate of potash, and a salt, made by treating sulphate of potash with an excess of sulphuric acid. The positives are thin zinc plates, two in each cell. To charge the battery, the dry salts are placed in the cell and water poured on. This, M. Chutaux claims, is an advantage, as no liquid acids have to be employed. The batteries are said to be very free from smell, or from the evolution of gases likely to tarnish silver, &c. The No. 1, or smallest machines, have two electro-magnets, worked by eight elements, and will drive a sewing machine. These cost, with battery, £10, and are said to cost fivepence for ten hours' work. No. 4 size machines will drive a fretting saw, have four electro-magnets, worked by sixteen elements, and cost £14, and are said to cost eightpence per ten hours' work.

We have received a pamphlet on the "Protection of Life and Property from Lightning during Thunderstorms," by W. Mc Gregor, of the Indian Telegraph Department. Published by W. J. Robinson, Bedford.

The s. s. *Charante*, repairing ship of the French Government in the Mediterranean, came into Toulon on March 20th, after having repaired the cable between Cape Corse and Leghorn, in which a fault had developed 30 kilometres from the Corsican coast, in 525 metres depth. After this the *Charante* was placed at the disposal of the Italian Government, for whom she executed the following works in the straits of Messina: The picking up of a three-conductor cable between Cannitello (Calabria) and Ganzirri (Sicily); submersion of a cable, with one conductor, between the same points; and repair of the cable from Bagnara (Calabria), and Cape Mazzona (Sicily).—*Annales Telegraphiques.*

Electric bells worked by batteries often get out of order, and the batteries require certain attention. To remedy this, Messrs. Siemens have constructed a bell worked by a magneto-electric induction machine. A Siemens' armature works by means of a handle between six permanent magnets, and produces a permanent current which works the bell. To ring the bell the handle has simply to be turned,—the machine can be fixed against the wall and occupies very little space.—*Moniteur Industriel Belge.*

The *Daily News* of June 20th, states:—In the Telegraph Market Anglo-American and Direct United States were both firm, and advanced 1½ and ¾ respectively in consequence of some freely circulated rumours of amalgamation or joint working agreement.

The Western Union Telegraph Company have declared a quarterly dividend of 1½ per cent, on the capital stock of the company for the three months ending 30th inst.

The Traffic Receipts of the Direct United States Cable Company, Limited, at 3s. per word, for the week ending 17th June, were £2,900, and for the week ending 24th June, £2,800., and the receipts of the same company, at 3s. per word, for the present year up to the 10th June, were £51,000.

The Eastern Telegraph Company announce that, subject to final audit, the accounts show a balance which will enable the directors at the meeting on 12th of this month to recommend a final distribution of 2s. 6d. per share, free of income tax, making, with previous payments, a dividend for the year ended 31st March last, of 5 per cent., leaving a balance of about £20,000 to be carried to reserve.

At a general meeting of the Madras Railway Company, the chairman, in moving the adoption of the report, stated, amongst other matters, that "they had received a proposal from the Government of India for a transfer of their telegraph lines, and as the terms of purchase offered were reasonable, the Board had expressed the willingness to make the desired arrangement. The terms were that the Government should pay them the whole capital cost at which the lines account stood in the company's books, renting to the company a certain number of wires."

The report of the Bombay, Baroda, and Central India Railway states that the Government being desirous to acquire the telegraphs of the railway companies in India, the Board have concluded an arrangement with the Secretary of State, under which this company's telegraph lines (exclusive of the instruments and offices, which remain the property of the company) will be transferred to Government, who will let to the company at a fair rent such telegraph wires as are required for railway purposes, and will repay to the company the capital cost of the railway telegraph line and stores in hand, amounting to about £22,800. It would thus appear that the Government of India are about to buy up all the railway telegraphs.

Death has been busy of late among our railway telegraph superintendents. Mr. Edward Cripps, of the London, Brighton, and South Coast Railway, died on May 15th, and Mr. Henry Moxon, of the Lancashire aud Yorksnire, died on the 20th ult.

POLAR AURORAS.

By M. J. PLANTÉ.

"NOTHING should be neglected which can bring "about a complete conviction of the theory of the "forces of nature, and cause the uncertainty of "investigation to give place to the security of "known truth. Should we, for exampie, be so "sure of the theory of the rainbow had we not re-"produced that brilliant phenomenon with all its "peculiarities, by means of a jet of watery spray "thrown up in full sunshine? The experiments "of the laboratory are, though on a small scale, "useful, and therefore to be valued."

These words, spoken by an illustrious member of the Academy, M. Babinet, encourage me to pursue the examination of the analogies between the effects of electric currents of high tension and the great natural electric manifestations. The experiment of De la Rive has already demonstrated the connection of polar auroras with terrestial magnetism; but it does not sufficiently explain all the circumstances which accompany them. In the experiments described in the present paper, the electric stream flows in connection with aqueous masses as in the atmosphere, and a series of phenomena, completely analogous to the various phases of polar auroras, are observed.

1. If the positive electrode of the powerful secondary battery used in these experiments is brought into contact with the wet sides of a vessel containing a solution of salt and water, into which the negative electrode has been previously inserted, the following phenomena, varying as the distance from the liquid is increased or diminished, will be observed: either a crown formed of luminous particles making a circle around the electrode (fig. 1), or an arc bordered with a fringe of brilliant rays (fig. 2), or a wavy line which vibrates rapidly (fig. 3). This undulatory movement especially, offers a complete analogy with that which has, in the auroras, been compared to the windings of a serpent, or to the motions of drapery shaken by the wind.

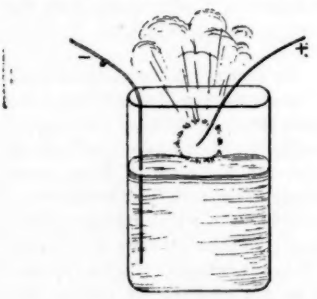

FIG. 1.

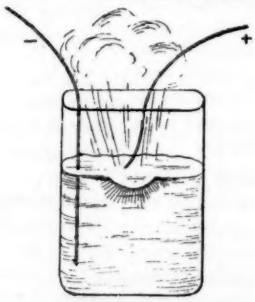

FIG. 2.

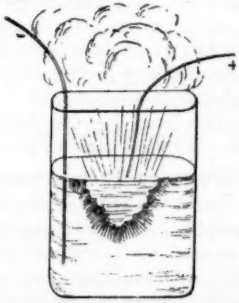

FIG. 3.

2. Although yellow light is predominant in these experiments, in consequence of the employment of salt and water, there have been observed, at those points where the water arising from the condensed vapour is less charged with salt, purple and violet tints similar to those of the aurora.

3. The rays of the luminous arc are produced by the flow of the electric stream into the liquid; the vacuum which results becomes again gradually filled up, new rays are formed, and an explanation is thus furnished of how the jets of light in the aurora *dart* or appear to be thrown out and received every moment.

4. The circle or dark segment formed, in the auroras, by the mist or the nebulous veil which the electric stream meets with, corresponds to the humid circle or segment which, in the experiment, surrounds the electrode, and round which the voltaic current spreads itself.

5. The form of the arc in the voltameter is due to the fact that the liquid does not entirely surround the electrode; but, if the wire is more deeply immersed, waves and complete luminous circles are produced; just as in the auroras where the arc is often considered as the part, visible to the observer, of a complete luminous circle.

6. The liquid is violently agitated by the electric blast, eddies and luminous rings are formed by the shock of the electrified waves one against the other, and, if only a small quantity of liquid is used, a luminous ebullition at last takes place, corresponding with that fluctuation of light which also characterises the polar auroras.

7. The watery vapour is produced all the more quickly and in greater quantity, as the electrode sinks more deeply in the liquid. This phenomenon, which the strongest batteries of static electricity hardly give evidence of, is worthy of particular attention; for it explains, in a natural manner, the abundant falls of either rain or snow which have always been observed in connection with polar auroras.

8. The noise which accompanies these experiments corresponds with that which has often been heard during auroras, when the distance has been comparatively small; it is produced by the vapourization resulting from the streams of electric fire passing into the liquid mass.

9. The magnetic disturbances caused by auroras are reproduced in the experiments by placing a magnetized needle near the circuit. The deviation increases or diminishes as the luminous arc is more or less developed in the liquid.

10. The facts mentioned indicate that auroras must be produced by a flow of *positive* electricity; for the luminous phenomena are the same as those of the voltameter, and the negative electrode shows nothing like them.

11. But are polar auroras the result of a discharge between the positive electricity of the atmosphere and that of the earth assumed to be negative? If this were so, the fall of lightning ought to be frequently observed at the poles, or gleams and luminous tufts be seen upon the prominent points of the surface of the ground, forming the counterpart of the phenomena which take place in the air. Observation, however, shows that such effects do not take place. I should be inclined therefore to think that it is the imperfect vacuum of the upper regions which, acting as an immense conducting envelope, plays the part of the negative electrode in the above described experiments; and that the positive electricity flows away towards the planetory spaces, and not towards the earth, through the fogs and frozen mists which float above the poles.

12. As for the origin of this polar electricity, it has been conceded that it comes from the equator and from the tropics. It may, however, be objected that the electrified clouds ought to discharge themselves in the course of so long a journey; and it is, in fact, known that storms become more and more rare as we approach the poles. My previous experiments, and others as yet unpublished, having led me to consider the celestial bodies as being charged with positive electricity (the only kind of electricity, perhaps, which exists), I should be inclined to regard the earth itself as charged with positive electricity, discharging itself, by means of simple omission, from both land and sea, radiating from the whole surface, at the poles as well as at the equator, but producing very different effects in consequence of the opposite meteorological conditions of the atmosphere in the two regions.

If this last hypothesis be admitted, it might be concluded that polar auroras result from the diffusion in the upper strata of the atmosphere around the magnetic pole, of the positive electricity arising from the polar regions themselves, either in obscure radiations when there is no interposed obstacle, or converted into heat and light through contact with watery masses either in a solid or liquid state, the latter being vapourized with noise, and precipitated afresh in the form of rain or snow upon the surface of the earth.—*Bulletin de l'Association Scientifique.*

Electrical Science in Foreign Journals.

Carl's Repertorium fur Experimental-Physik. Vol. xii., No. 2.

On a New Fundamental Law of Electro-dynamics. By R. Clausius.—In explaining the phenomena of electro-dynamics, W. Weber has stated a law with respect to the mutual effect of two electric particles when in motion. Let e and e' be the two particles, and r their distance apart, which is to be regarded as a function of the time t. According to Weber, these particles repel each other in a manner represented by the following formula, in which c is a constant:—

$$\frac{e\,e'}{r^2}\left[1 - \frac{1}{c^2}\left(\frac{dr}{dt}\right)^2 + \frac{2}{c^2} r \frac{d^2 r}{dt^2}\right]$$

Helmholz has raised certain objections to this formula, and the author, upon grounds quite distinct from those upon which Helmholz has based his objections, has come to the conclusion that the formula in question does not represent the actual facts. The author's investigations have led him to the statement of another law in this case.

In starting with the idea that the electro-dynamic action upon each other of two moving electro particles takes place through the medium which separates them, we must not assume that this action is dependent merely upon the *relative* motion of the particles, but an influence must be attributed to the *absolute* motion of each particle; for example, if two electric particles move in a parallel direction and with equal rapidity, and are as a consequence equally at rest, they, nevertheless, may exercise an electro-dynamic influence upon each other, for as regards the intervening medium they behave otherwise than as particles really at rest.

The latter part of the paper is devoted to the development and statement of the formulæ used to express the new electro-dynamic law put forward by the author.

On the Thermo-electric Conditions of various Metals in Melting and Re-cooling.—By A. Von Mineralli.

The condition of thermo-elements during the melting of the more fusible constituent has been investigated by Herr Abermayer in the case of several metallic combinations. It has been shown that in the case of the combinations experimented upon, the electro-motive force is the same during the melting as during the cooling.

The irregularities observed in the case of the Bismuth-iron element rendered it, however, desirable to undertake further experiments upon the combination of bismuth with certain other metals, and at the same time to investigate the conditions of certain other metallic combinations. The experiments were directed to two ends. First, the determination of the electro-motive force at the point of re-cooling; and secondly, the ascertaining of the changes in electro-motive force before, during and after melting and cooling. It was ascertained from preliminary experiments, that in the case of the thermo-elements experimented upon, there was no sudden or violent alteration in electro-motive force either during melting or cooling.

The combinations employed were the following—lead-zinc, lead-antimony, bismuth-iron, bismuth-copper, bismuth-platinum, bismuth-antimony, tin-zinc, tin-antimony, iron-tin, lead-iron. The results are given in a tabular form, and also in the form of a diagram, where the abscissæ represent the temperature and the ordinates the electro-motive force. The curves plotted from actual observations during melting mostly coincide with those representing the observations during cooling. A deviation is observable in the bismuth elements and partially so in the case of the zinc-antimony couple, which may be attributed either to some over-heating, or to the fact that with impure bismuth the melting point does not coincide with that

at which it become again solid, but is somewhat higher. The curves show that the electro-motive force varies continuously with the temperature.

Journal Télégraphique. Vol. iii., No. 15.

The Phonotelegraph.—By Paul la Cour, of Copenhagen.—A description of this new system of telegraphy has been recently given in these columns. The present paper gives a rather more detailed description of the proposed method of multiple working by means of tuning-forks of varying pitches.

The Telegraph in the Dutch East Indies in 1874.—From this summary of a report upon the telegraphs in Java and Sumatra, it appears that a peculiar method of suspending wires along the roads is adopted in those islands. An iron wire is stretched across the road and fastened to a tree at each side. From the centre of this wire is suspended the conductor, which thus follows a course above the middle of the road. Leclanché batteries are mostly employed, and it is stated that the use of the Hughes apparatus has been discontinued, as satisfactory results were not obtained with it. The instruments have been returned to Holland.

Proceedings of Societies.

PHYSICAL SOCIETY—10TH JUNE, 1876.

PROFESSOR G. C. FOSTER, President, in the chair.

Mr. W. J. Wilson exhibited and explained a reflecting tangent galvanometer which he has recently designed, for the purpose of exhibiting the indications of the instrument to an audience, and so arranged that the divisions on the scale show, without calculation, the relative strengths of different currents. It should be observed at the outset that this object cannot be attained by attaching a mirror to the needle, as in the ordinary galvanometer, as the angle passed over by the reflected ray is double that through which the needle is deflected. In the arrangement exhibited, the beam of light, after passing through a small orifice traversed by cross wires, is reflected vertically by a fixed mirror; the ray then passes through a lens, and is again reflected from a small plane mirror, parallel to the first, which is rigidly fixed on a small magnetic needle. By this means the ray becomes again horizontal and, since the light now falls on the second mirror always at the same angle, the extent of motion of the ray is identical with that of the needle, and, if the scale be one of equal parts placed in the magnetic meridian, the indications on it will be proportional to the tangents of the angles, and therefore to the strength of the currents. The needle and mirror are suspended by a silk fibre and a bent strip of aluminium, the ends of which dip into water in an annular trough, is attached to the needle in order to check its oscillations. A series of observations taken with varying resistances introduced into the current showed that the indications are very reliable.

Mr. S. P. Thompson then exhibited an electro-motor clock, made by Mr. W. Hepworth, of York, and provided with a commutator of Mr. Thompson's design. This part of the instrument is very simple, and reverses the current at each single oscillation by means of two light springs resting on inclined planes. The motion of the pendulum drives the train of wheels by a modification of the gravity escapement, and a very small battery power is sufficient.

Professor G. Fuller, C.E., exhibited and described his "Electric Multiplier," an instrument which may be looked upon as an automatic electrophorus. An insulated plate of vulcanite is supported in a vertical position, and on each side of it is an insulated metallic plate, and these can be moved together to and from the vulcanite by rotating a handle. When these plates are far apart, two metallic arms provided with points are made to pass one on each side of the vulcanite plates. One of these is insulated, and is provided with a rod terminating in a knob, which at a certain point in its path almost touches the metallic plate on the opposite side of the sheet of vulcanite. The other arm is in connection with the earth. The action of the instrument is as follows:—A charge of, say negative electricity, having been given to the insulated arm, it is passed over the face of the vulcanite, while positive is drawn up from the earth and thrown upon the opposite face by the insulated series of points. These arms are then removed, and the two metallic plates are brought into contact with the vulcanite. Call the side of the plate charged with negative electricity A, and the other B. The negative of A induces positive on the near face of its metallic plate and repels the negative. This passes, by a strip of tin-foil joining the two faces of the vulcanite to the other metallic plate, neutralising its free positive; and when the plates are moved away from the vulcanite that from A is charged with positive, and that from B with negative. Before reaching its extreme position, this latter communicates its charge to the insulated arm by the brass knob, and the electricity is then distributed over the face A. At the end of its path, it is momentarily connected to earth. It will be evident that the effect of again bringing the plates in contact is to increase the charge of positive electricity on the metallic plate opposite the face A. With the small model exhibited, Professor Fuller has frequently obtained sparks an inch in length.

Professor Guthrie then exhibited and employed Professor Mach's apparatus for sound reflexion, which is one of an interesting series of appliances designed by him for the demonstration of certain fundamental principles in physics. It consists of a mathematically exact elliptical tray which is highly polished. and provided with a close-fitting glass cover. The tray is covered with pulverized dry silicic acid, and a Leyden jar frequently discharged between two small knobs at one of the foci, when the silicic acid arranges itself in fine curves around the other focus.

ANSWERS TO CORRESPONDENTS.

W. H. BIRD (Lowestoft).—It is decidedly illegal to deface the coin of the realm.

E. PAGE (1, Cambridge-gardens). — We should think that your mode of making an induction coil would not answer.